Physiologic Response to Bottle-Feedings in Infants with Congenital Heart Disease: Three Case Studies

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Abstract

Neonates with congenital heart disease (CHD) commonly experience feeding difficulties and, thus, are at increased risk for altered growth and development. Physiologic stability during feedings is a concern for this population who often lack suck-swallow-breathe coordination and may expend more energy than consumed in a feeding. The purpose of this study was to describe the physiologic response of neonates with feeding. In this multiple case study design, single bottle feedings were observed on three infants with various heart defects requiring surgical intervention within the first month of life. Heart rates, respiration rates, and oxygen saturations were collected before, during, and after feeding. Feeding skills were assessed using the Early Feeding Skills assessment tool (EFS). Compared to baseline, two infants' heart rates were elevated during the feeding and remained elevated throughout post-feeding. In these two infants, oxygen saturations dropped slightly from 88% at baseline to 85% in one infant during feeding and from a baseline of 85% to 75% in the other infant post-feeding. The third infant showed little change in heart rate and oxygen saturation throughout the feeding. The two infants who demonstrated concerning physiologic responses also had lower scores on the EFS. Physiologic instability with a repeated and critical task such as feeding is an urgent concern for neonates with CHD. Further research is needed in neonates with CHD to describe feeding skill and physiologic responses to feeding in order to develop better interventions to promote feeding success. Since breastfeeding is associated with more adaptive physiologic responses, research needs to include comparisons between bottle feeding and breastfeeding in this population.

Background

More than 40,000 infants are born each year with congenital heart disease (CHD), which equates to about 8 per 1,000 live births (Mozaffarian D, Roger VL, et al.). About 25% of the total number of infants with congenital heart disease have complex defects. Advanced technology and increasing knowledge about congenital heart disease have promised better outcomes for infants diagnosed with these defects, and the survival rates are high (Hartman & Medoff-Cooper, 2012). Consequently, the increased life expectancy of this population creates a different set of challenges. Infants with CHD are at increased risk for experiencing malnutrition (Jadcherla, Vijayapal, & Leuthner, 2009), cyanosis, heart failure, and recurrent infections (Polat, Okuyaz, Hallioglu, Mert, & Makharoblidze, 2011), all of which negatively influence growth and development. Nutrition and feedings are a primary concern for these vulnerable infants because proper nutrition is imperative to achieve desired growth and developmental milestones (Jadcherla et al., 2009). Longer hospitalizations often result as well due to the inability of infants to achieve desired feeding outcomes before discharge, leading to increased parental stress (Medoff-Cooper, Naim, Torowicz & Mott, 2010).

Human milk is the preferred source of nutrition for well, preterm, or ill infants (Medoff-Cooper et al., 2010) because of the beneficial nutrients and morbidity-specific protection it delivers at different time periods (Meier, Bigger, & Engstrom, 2013). Human milk is important for the initial colonization of the infant gut and helps develop critical gut microbiota, which helps prevent necrotizing enterocolitis (NEC) in premature infants (Meier et al., 2013). The beneficial elements of human milk, specifically colostrum, are believed to reduce the incidence of feeding intolerance secondary to issues related to the gut in infants with CHD for similar reasons (Medoff-Cooper et al., 2010). Studies conducted with the premature infant population have reported that the use of human milk was linked to a decreased incidence and severity of nosocomial infections, necrotizing enterocolitis (Rodriguez, Miracle & Meier 2005), diarrhea, bacteremia (Gartner, Morton, Lawrence et al., 2005), as well as the prevention of sepsis (Furman, Taylor, Minich & Hack, 2003). Premature infants and infants with CHD are comparable populations because they are both at risk for increased energy expenditure and depleted metabolic reserves (McCain, Fontaine & Vasquez, 2010; Medoff-Cooper et al., 2010). These conditions further indicate the critical need for appropriate nutrition.

Even with the known benefits of human milk, breastfeeding infants with CHD in the hospital is not routinely implemented (Medoff-Cooper et al., 2010). Many believe that the act of breastfeeding is physically strenuous on an infant with a congenital heart defect (Marino, O'Brien, & LoRe, 1995). Neonates born with CHD have difficulties with feedings commonly due to dysphasia or dysfunctional swallowing reported after neonatal open-heart surgery (Hartman & Medoff-Cooper, 2012). However, other studies have shown that breastfeeding actually results in higher oxygen saturations than bottle feedings, suggesting breastfeeding is less strenuous in this population (Marino et al., 1995). This pattern of decreased oxygen saturations with feedings is consistent with data collected during bottle feedings of preterm infants (Meier 1988; Bier et al., 1993). Extended periods of desaturation, which is possible during bottle feedings, is taxing on an infant's oxygen reserves and leads to fatigue and poor growth (Marino et al., 1995).

A multitude of evidence has demonstrated that human milk is the optimal source of nutrition for infants, and this evidence is widely accepted by health care clinicians.

Many studies have been conducted surrounding feeding methods for critically ill infants, especially premature infants. However, the optimal feeding method for critically ill infants with congenital heart disease is unknown. This lack of sound evidence is a major obstacle for establishing patterns of best practice for feeding infants with complex congenital heart disease. These infants are at risk for impaired growth and nutrition due to poor feeding abilities. A better understanding of the physiology linked to each feeding method can help determine if there are benefits of one method over another. The purpose of this study is to analyze the physiologic responses to bottle feeding in newborn infants with congenital heart disease. Our aims were to (1) describe infant physiological response to bottle feeding and (2) describe infant feeding skill during bottle feeding.

Methods

We used a multiple case study design for this exploratory study.

Sample

Infants born with complex congenital heart disease undergoing neonatal cardiac surgery were recruited from the cardiothoracic intensive care unit and the step-down unit at the participating children's hospital. Exclusion criteria included presence of co-existing, non-cardiac congenital defects or syndromes because of potential effects on feeding response and feeding skill. Study staff approached families, provided information about the research and explained the opportunity for voluntary involvement in the study.

Measurements

Physiologic response was measured using heart rate, respiratory rate, and oxygen saturations. Data were collected every 15 seconds for Infants 1 and 2 and every 60 seconds for Infant 3, starting 30 minutes before a feed and ending 60 minutes after completion. The Bedmaster research tool exported the data from the bedside cardiorespiratory monitors, stored it in the central database server for each study participant, and then sent it to the study's primary research PC.

Feeding Skill. The Early Feeding Skills Assessment (EFS) is an observational checklist for assessing infant readiness for and tolerance of feeding and for profiling the developmental stage of specific feeding skills. It is appropriate for use in either preterm or full-term infants through 54 weeks post-conceptual age (personal communication, S. Thoyre, July 24, 2006). Three subscales are included: Oral Feeding Readiness, consisting of 4 yes/no items related to signs of readiness with a Cronbach's alpha coefficient of 0.70 (Boonmee & Pickler, 2006); Oral Feeding Skill, consisting of 28 items related to engagement, organization, swallowing, and physiologic stability with a Cronbach's alpha coefficient of 0.76 (Boonmee & Pickler, 2006); Oral Feeding Tolerance, consisting of 2 items related to infant state and muscle tone after feeding with a Cronbach's alpha coefficient of 0.74 (Boonmee & Pickler, 2006). Each subscale is scored separately with a possible range of 1-3. Scores of 3 indicate areas of strength; scores of 2.0-2.9 indicate areas of some clinical concern; scores of 1-1.9 indicate areas of major clinical concern. The EFS was scored from a video recording of each feed, by trained research staff. Reliability was supported through coding by two trained coders for all feedings. Discrepant codings were discussed and consensus was reached.

Infant Health History was obtained from the medical record and included gestational age, gender, type of feeding, and type of cardiac defect.

Procedure

Following informed consent, plans were made for data collection during one feeding time chosen by mother. Collection times varied depending on the length of time the infant fed. Data collection, including video recording of the infant, began 30 minutes before beginning of the feeding and ended 60 minutes after the feeding was completed. Mothers fed each infant and the Early Feeding Skills (EFS) assessment was completed later by study staff through coding of the video recording. Physiologic data were gathered from the continuous electrocardiographic readings and pulse oxygenation readings stored in the central database server used to monitor research participants on the unit. The Bedmaster system from Excel Medical Electronics exported the data from the feeding time period to a destination folder in the study's primary research PC.

Data Analysis

Data were analyzed descriptively with means and standard deviations for each measure. Trajectories of physiologic measures and graphical displays of feeding skill were developed. Intraindividual change and interindividual differences were analyzed visually in these case studies.

Results

Three infants were recruited from the cardiac units at a large Midwestern private, non-profit children's hospital. Infant characteristics are reported in Table 1.

All three infants were bottle fed breast milk during the data collection time period.

Heart Rate

Infant 1 experienced an increase from a baseline heart rate of 132 beats per minute (bpm) pre-feeding, to 142 bpm during-feeding, and 136 bpm post-feeding, with the peak heart rate reaching 162 bpm, post-feeding. Overall, the heart rate remained close to the baseline throughout the collection period. Infant 2's heart rate jumped from a pre-feeding baseline heart rate of 129 bpm to 139 bpm during-feeding. The heart rate continued to trend up and remained elevated post-feeding, peaking at 161 bpm. Infant 3's heart rate gradually trended up from 149 bpm at the onset of feeding to 162 bpm during, and remained elevated at an average of 156 bpm post-feeding. The heart rate for Infant 3 peaked at 182 bpm post feeding. Heart rate data and trajectories are reported in Table 2 and Figure 1.

Respirations

Respiration rate varied greatly throughout the feeding period for Infant 1. Infant 1 exhibited tachypnea in all three phases of data collection, reaching 93 breaths per minute post-feeding. Conversely, Infant 1 reached a minimum of 14 breaths per minute during the post-feeding period. Respiration rate data was not collected for Infant 2 due to equipment failure. Infant 3 also exhibited periods of tachypnea throughout all three phases of data collection with a range between 29-109 breaths per minute. Infant 3's peak respiration rate occurred pre-feeding at 109 breaths per minute and the lowest respiration rate occurred post feeding at 29 breaths per minute. Respiration Rate data and trajectories are reported in Table 2 and Figure 1.

Oxygen Saturations

The oxygen saturation for Infant 1 remained relatively stable with a range of 80-99%. This infant had one noticeable oxygen desaturation, down to 80%, post-feeding. Oxygen saturation stayed close to the baseline of 92% throughout the entire feeding period. Oxygen saturation was affected post-feeding for Infant 2 when it dropped from an average of 85% pre-feeding and during-feeding to 75% post-feeding. Infant 2 experienced a desaturation down to 61% during this post-feeding time period as well. For Infant 3, oxygen saturation dropped from pre-feeding average of 87% to 85% during the feeding period but returned to 88%, similar to pre-feeding baseline, during the post-feeding period. Oxygen saturation dropped from 91% immediately before initiation of bottle feeding to 83% at the onset of feeding and did not climb back up to 90% until 11 minutes after completion of the fed. Oxygen Saturation data and trajectories are reported in Table 2 and Figure 1.

Feeding Skills

Pre-feeding baseline for Infant 1 and Infant 2 demonstrated physiologic stability through their vital signs and scored a 2 on the oral feeding readiness assessment, indicating an area of some clinical concern. Infant 1 and Infant 2 both demonstrated energy for the feeding and appropriate muscle tone. Infant 3, however, had an oxygen saturation of 86% prior to feeding and scored a 1 on the oral feeding readiness assessment, indicating an area of major clinical concern.

Infant 1 scored in the 2.0-2.9 range for all the subscales of the Early Feeding Skills Assessment (EFS) oral feeding skill assessment, scoring the highest in all 4 subscales compared to Infant 2 and Infant 3. Infant 1 was alert for the feeding and maintained tone and energy for feeding. However, he did not open his mouth promptly when his lips were stroked and the initiation of sucking was delayed for some onsets. Infant 1 also had occasional loss of fluid when swallowing and had some hard swallows, lowering his score on his ability to coordinate swallowing. Infant 1 took 35 mL of milk in 10 minutes and achieved the highest feeding efficiency at 3.3 mL/min.

Infant 2 also scored in the 2.0-2.9 range for all subscales of the oral feeding skill assessment. This category indicates an area of some clinical concern in regards to the infant's ability to be engaged in the feeding, organize oral-motor functioning, coordinate swallowing and remain physiologically stable. Infant 2 was awake but not completely alert at the beginning of feeding. He occasionally opened his mouth promptly when lips were stroked and had some delayed and weak sucking. Evidence of difficulty with the coordination of swallowing was exhibited by some fluid loss, gurgling sounds, and hard, multiple swallows. Infant 2 also had some occasional dips in oxygen saturation throughout the feed. Infant 2 took 60 mL of milk in 39 minutes and achieved a feeding efficiency of 1.5 mL/min

All subscales of Infant 3's oral feeding skill assessment fell in the 1.0-1.9 range, except swallowing, which scored 2.7. The 1.0-1.9 range signifies an area of major clinical concern. Infant 3 displayed the most physical characteristics of distress throughout the bottle feeding time period. He was drowsy at the onset of feeding and displayed a late loss of tone and energy. Infant 3 never opened his mouth promptly when his lips were stroked and sucking was weak and delayed for all onsets. Infant 3, however, did not show any loss of fluid while swallowing. Physiologically, Infant 3 had frequent dips in oxygen saturation, occasional dips 20% below the baseline heart rate, frequent increased work of breathing and occasional grunting. Infant 3 took 6 mL of milk in 26 minutes and achieved a feeding efficiency of 0.23 mL/min. Early Feeding Skill Assessment scores are reported in Figure 2.

Summary of Results

The maximum heart rate exhibited by all three infants was during the post-feeding period and the minimum oxygen saturation for all three infants occurred post-feeding. Also, all three infants scored below a 3 on all subscales of the EFS, which is indicative of at least some degree of clinical concern.

Discussion

In this case study, physiologic data including heart rate, oxygen saturation, and respiration rate, along with an assessment of feeding skills, were evaluated for three newborn infants with various congenital heart defects during a bottle feeding. While breastfeeding is by far the superior means of feeding, due to the nutritional benefits of breastmilk and perceived physiologic impact of bottle feeding, the great majority of infants in American newborn intensive care units (NICUs) are fed breast milk by bottle (Pineda, 2011).

A quality feeding can be defined as a complex event in which the infant is safe, physiologically stable, actively participating, behaviorally organized generally and in oromotor activity, and comfortable (Ross & Philbin, 2011). Physiologic stability is defined as stable vital signs, good color, and good muscle tone when the infant is alone in bed or during simple handling (Browne & Ross, 2001). Stable vital signs are defined as a respiratory rate between 40 and 60 breaths per minute (or another range specified for that particular infant), a heart rate within 20% of recent resting levels (or a range specified for that particular infant), and blood oxygen saturation levels within the range specified by unit guidelines (or within a range specified for that infant). An infant who is breathing outside of the defined respiratory rate is working harder to maintain oxygenation. Good color is defined as pink in face and body with minimal to no paleness, mottled color, or localized duskiness/ cyanosis. Good tone is defined as moderate flexion across shoulders, neck, trunk, and hips (Ross & Philbin, 2011).

Through monitoring physiologic data in this study, we were able to analyze the infant's response to a bottle feeding and note signs of distress. We found that all three infants demonstrated physiologic distress and less than optimal feeding skills. Data collected during a feeding for Infant 2 and 3 was prior to their discharge and post-operatively, while Infant 1 had data collected pre-operatively. In infants with CHD who have had surgical intervention, the development of swallowing and feeding-related difficulties are a frequent concern due to factors such as a high incidence of dysphagia, preoperative acuity, duration of intubation, vocal cord injury or type of surgical procedure (Einarson & Arthur, 2003; Skinner, Halstead, Rubinstein, Atz, Andrews & Bradley, 2005). Therefore, an infant with CHD who previously had surgical intervention may experience more difficulties with feeding than an infant who has not had surgical intervention. Infant 2 and 3 both had surgical intervention and scored lower on the EFS compared to Infant 1, who was preoperative.

Each infant exhibited varying degrees of physiologic distress during the data collection time period. Infant 3 showed the most concerning signs of distress in his vital signs and low scores on the EFS. Infant 3 was also the only premature infant out of the three case studies. These findings heighten an awareness surrounding the effects of bottle feeding in critically ill infants and generates questions about whether it is the best feeding method. Our findings also highlight a potential problem with nursing identification of infant feeding readiness.

Heart Rate

All three infants exhibited a peak in heart rate post feeding that was greater than 20% above their baseline, resting heart rate. This variation in heart rate is considered unstable. Infant 1 and 2 experienced an increase in heart rate immediately upon initiation of the feed. An increase in heart rate may be related to the physical task of sucking on a bottle and removing milk from the nipple.

In this study, Infant 3 displayed an increase from baseline heart rate throughout the feeding for up to 18 minutes after the feed that corresponded with a decrease in oxygen saturation until the same time period after the feed. This physiologic response suggests that the work of feeding continued even after the nipple was removed for the final time.

More research is needed to examine and compare the changes in heart during breast and bottle feeding.

Respiration Rate

Changes in respiratory control may occur when infants' state of arousal decreases or when they become fatigued during feeding. Active sleep, the sleep state most likely if the infant falls asleep during feeding, depresses respiratory and arousal responses and many respiratory reflexes (Brouillette & Côté, 1996). This is one reason why it is important to consider if an infant is ready or in an appropriate state to begin feeding because it can impact their success and physiologic stability. Breathing irregularities, including breathing pauses, often lead to significant and frequent episodes of desaturation during bottle feeding (Shiao, Brooker & DiFiore, 1996; Chen, Wang, Chang & Chi, 2000). Mathew (1991) noted that recovery from respiratory dysregulation during feeding depends on the duration of breathing periods and ability of the infant to increase ventilation during these breathing breaks. Therefore, when an infant lacks suck, swallow, breathe coordination, they have difficulty regulating their respirations, which then impacts their oxygen saturation. Infant 1 and 3 had highly variable respiration rates and Infant 3 showed visible signs of increased work of breathing, including head bobbing. Infant 3 also had difficulty integrating breaths within a sucking burst and experienced a desaturation during feeding, possibly related to the inability to regulate respirations enough to maintain adequate oxygen saturations.

Current research has focused on increased energy needs as the primary cause of malnutrition in infants with CHD (Salzer, Haschke, & Wimmer, 1989; Schwartz et al., 1990). A decrease in oxygen saturation (perhaps from respiratory distress similar to these infants' experience) is taxing on an infant's metabolic reserves and can deplete energy they are trying to consume from a feeding, compromising their increased demand for energy and affecting their nutritional status.

Oxygen Saturations

Marino (1995) found differences in the cardiorespiratory effort of infants with CHD during bottle versus breastfeeding by specifically examining oxygen saturation. Characteristically, the infants in this study experienced a pattern of drops in oxygen saturation that corresponded with the most vigorous sucking phases and a return to near baseline during less vigorous sucking.

Adequate oxygenation enables infants to maintain behavioral organization (Porges, 1994) and provides energy for the physiological work needed for effective and efficient feeding. Infants usually feed in a flexed, toward midline, body position. When they start to lose the ability to maintain this position, they may be showing signs of fatigue. Infants who spend more of their feeding time in an awake state have higher mean oxygen levels during the feeding (Thoyre, 1997). Infant 1 and 2 were both more alert and awake than infant 3 and experienced desaturations post-feeding, but exhibited higher mean oxygen saturations during feeding than Infant 3. Infant 1 and 2 ended their feeding in a flexed, toward midline position whereas, Infant 3 experienced desaturations during-feeding and exhibited a late loss of tone by the end of feeding.

Adequate oxygenation is critical for the growth and development of these infants (Moyer-Mileur, Nielson, Pfeffer, Witte & Chapman, 1996; Cheung, Barrington, Finer & Robertson, 1999) and frequent desaturations may contribute to adverse developmental outcomes (Perlman, 2001).

Feeding Skill

Infant 3 was the only infant to score a 3 in any section of the EFS and that was with the Oral Feeding Tolerance Assessment. This subscale examined the infant's state and energy level post feeding. Compared to Infant 2 and 3, Infant 1 had not undergone surgical intervention and scored the highest on all scales of the EFS, as well as exhibited the most physiologic stability. This finding may be related to the increased difficulties with feeding after surgical intervention in the CHD population.

Each infant was assessed for oral feeding readiness immediately prior to feeding. All three infants scored less than 3, indicating lack of true readiness for feeding. Despite the signs of distress or lack of readiness displayed by each infant, including lack of energy, inattention to feeding, and drowsiness, all three infants were still prompted to feed by bottle. In addition, infants are able to actively communicate lack of readiness or distress throughout the feeding through cues such as a delay in opening the mouth when lips are stroked and delayed initiation of sucking. All 3 infants exhibited these cues to some degree throughout the feeding.

It is possible the individual feeding an infant may be unaware of the difficulties an infant is having during a bottle feed, which can negatively impact the infant in terms of feeding success and growth and development. Current research in preterm infant feeding shows that the infant's ability to feed well is closely related to the caregiver's ability to understand and sensitively respond to his physiology and behavioral communications (Thoyre & Brown, 2004; Pickler, 2011). Therefore it is important for nursing staff, parents, and those feeding infants in the critical care setting to be expert in identifying signs of distress and lack of readiness in order to determine appropriate feeding times. When oral feeding readiness and distress cues can be determined and understood clearly, nurses should have the ability to determine the need for extended nasogastric (NG) feedings. It is possible that the current expectations for progression of oral feeds is too high for these infants with CHD, furthering their inability to be successful.

The use of human milk is commonly promoted in the hospital setting, but is most often supplied to the infant in the form of a bottle feeding. Clinicians may be reluctant to promote direct breastfeeding due to losing the ability to measure and record intake volumes and control fluid quantity, which may be important with compromised cardiac function. However, there has been limited research comparing bottle feeding and breastfeeding in infants with CHD. In one study completed in the 1990s, breastfeeding and bottle feeding were compared by analyzing oxygen saturations in infants with CHD

(Marino et al., 1995). Results showed oxygen saturations during breastfeeding were significantly higher and less variable than saturations during bottle feedings. Four of the seven infants desaturated (Sao2 < 90%) during bottle feedings, but no infant desaturated during breastfeeding (Marino et al., 1995). These desaturations did not only occur during active bottlefeeding, but persisted up to minutes after completion of the feed. In Marino's study, two infants desaturated after bottle feedings, and no infant desaturated after breast feedings (1995). This pattern of decreased oxygen saturations is consistent with data collected during bottle feedings of preterm infants (Meier 1988; Bier et al., 1993). Extended periods of desaturation, which is possible during and after bottle feedings, is taxing on an infant's oxygen reserves and leads to fatigue and poor growth (Marino et al., 1995).

Additionally, previous research has shown that preterm infants who were fed directly at the breast received human milk feeds longer than infants who received expressed human milk in a bottle (Pineda, 2011; Smith, Durkin, Hinton, Bellinger & Kuhn, 2003). This evidence provides an additional point of support, along with improvement in oxygen saturation, for encouraging direct breastfeeding over simply receiving expressed breast milk in a bottle. It is important to consider the effects direct breastfeeding in the hospital setting will have on long-term breastfeeding outcomes, such as when the infant goes home. Continued research surrounding direct breastfeeding in the hospital setting is a critical need in order to help clinicians recognize and support the important benefits of breastfeeding.

Limitations

The major limitation of this study is that in this case study design, three infants were studied during a single feeding occurrence. Comparison cannot be made to subsequent feedings with the same infant. Additionally, a small number of cases with different health issues were used which makes it difficult to compare. There is also missing data regarding respirations from one infant due to equipment malfunction. However, our findings provide support for continued research.

Conclusion

Additional research is essential in order to determine best feeding practice for a vulnerable population of infants with CHD who struggle with feeding success and attaining optimal nutrition. A comparison of the physiologic response to bottle feeding versus breastfeeding needs to be further investigated in order to determine a best feeding practice. As nurses, it is imperative to be educated regarding signs of distress and feeding readiness, correlated physiologic data, which can be observed on patient monitors, and infant cues during a feeding. Implementing better practices to improve the feeding experience of infants with CHD can lead to long-term improvements in growth and development.

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Table 1

Infant Characteristics

	Infant 1	**Infant 2**	**Infant 3**
Gender	Male	Female	Male
Age at Birth	40 3/7 weeks	39 2/7 weeks	36 4/7 weeks
Age at observed Feeding	8 days	16 days	9 days
Diagnosis	VSD, AV canal, ASD, PDA	Single Ventricle, AV canal, TAPVR, Pulmonary Atresia, PDA	VSD, Interrupted Aortic Arch Type B, PDA
Procedure	Pre-op	Heart Cath, TAPVC repair, shunt	Repair of IAA, Closure of VSD
Type of feeding	Breast Milk	Breast Milk	Breast Milk

Note. VSD = Ventricular Septal Defect, AV = Atrioventricular, ASD = Atrial Septal Defect, PDA = Patent Ductus Arteriosus, TAPVR=Total Anomalous Pulmonary Venous Return, IAA = Interrupted Aortic Arch

Table 2

Means (Standard Deviations), Heart Rate, Respiratory Rate, and Oxygen Saturation of 3 Infants during Bottle Feeding

	Infant 1	**Infant 2**	**Infant 3**
	Mean (SD)	Mean (SD)	Mean (SD)
Pre HR	132 (8.67)	129 (1.88)	150 (5.19)
During HR	142 (6.09)	139 (6.6)	163 (4.16)
Post HR	136 (8.54)	140 (6.37)	157 (8.88)
Pre RR	48 (14.46)	n/a	70 (16.98)
During RR	46 (11.4)	n/a	63 (15.17)
Post RR	40 (14.83)	n/a	59 (18.24)
Pre SpO2	93 (1.27)	84 (5.12)	88 (1.65)
During SpO2	91 (1.49)	88 (5.62)	86 (1.65)
Post SpO2	91 (2.1)	76 (10.07)	89 (1.98)

Note. HR = Heart Rate, RR = Respiration Rate, SpO2= Oxygen Saturation

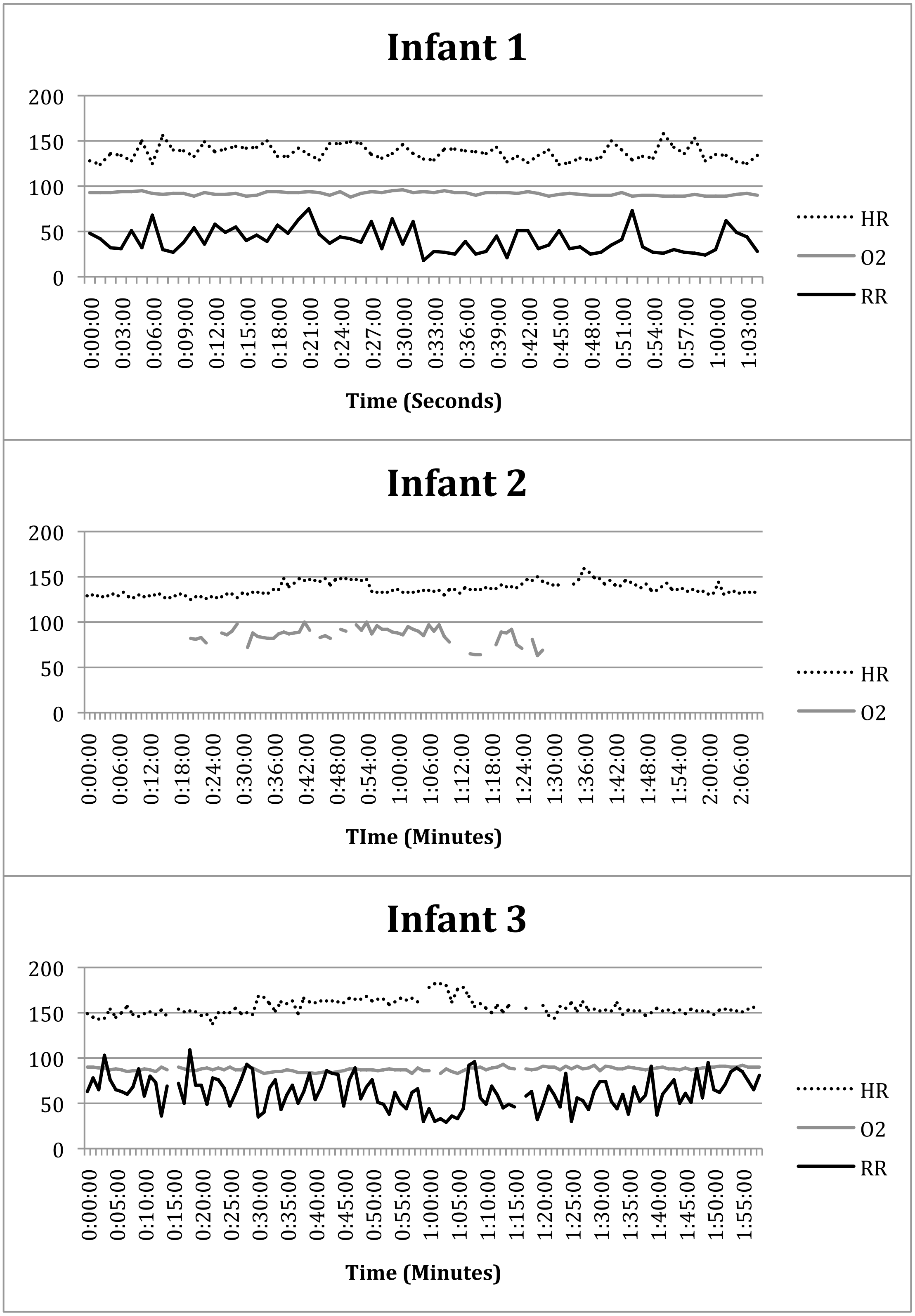

Figure 1. Infant physiologic response before, during, and after feeding. HR= Heart Rate (beats per minute), O2= Oxygen Saturation (%), RR= Respiration Rate (breaths per minute)

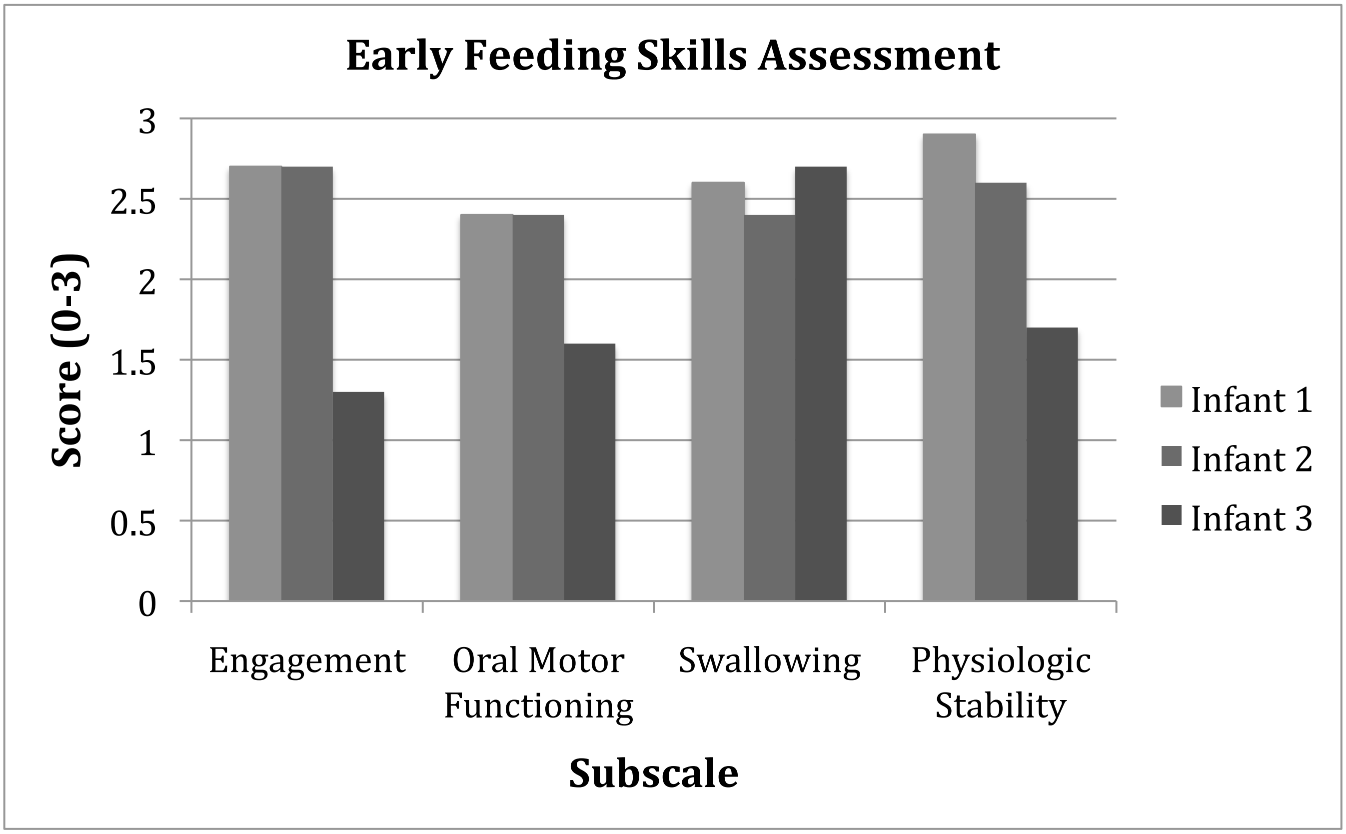

Figure 2. Early feeding skill scores by each infant